

Collecting Separated Isotopes at RIA for the Production of Radioactive Targets

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Outline:

1. Interest in radioactive targets at RIA
2. Radioisotope collection – ISOL separator
3. Collection - recoil separator
 - a. expected performance
 - b. beam heating issues



Introduction

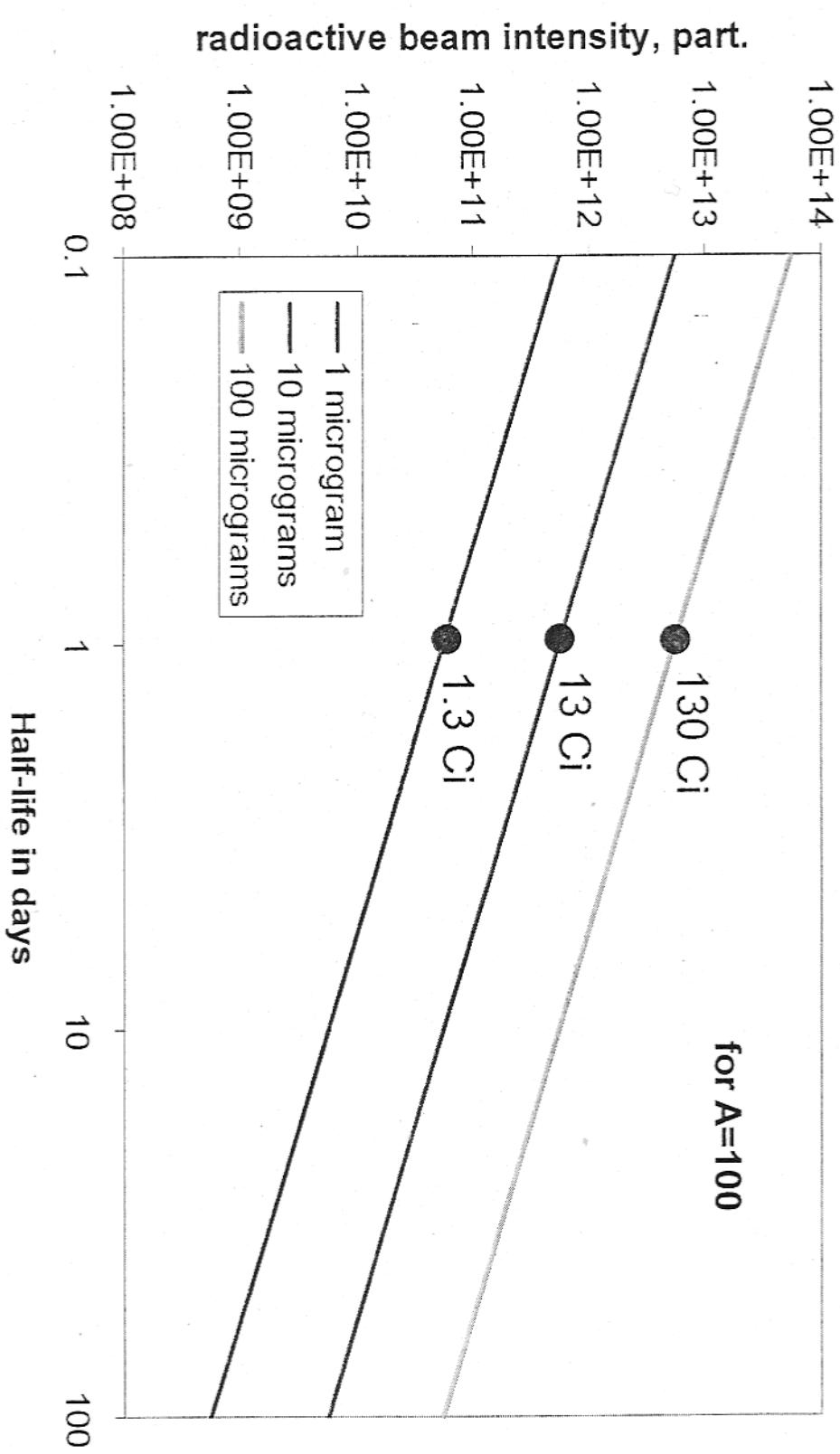
- Beyond RI beams on stable targets, there is interest in stable beams + rad. targets & RI beams + rad. targets
- For $T_{1/2} > 1$ day, rad. targets have some advantages (depending on the experiment)
 - ~10 $\mu\text{g}/\text{day}$ or $6\text{E}16$ atoms/day collected at $7\text{E}11$ pps

- RIA Applications Workshop, Los Alamos

- major finding - desire to collect / "harvest" long-lived species
- High specific activity for biomedicine & materials science
- X-sects. measurements for nuclear waste transmutation, stockpile stewardship and s-process nuclear astrophysics



Radioactive Target Accumulation



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Desired Target Purity

- Reaction studies may require $10^{-2} - 10^{-3}$ isotopic and elemental purities
 - Other experiments (such as activation exps.) may need up to 10^{-9} purity
 - Expectation for ISOL mass or A/Q recoil separations
ISOL: mass tailing = 10^{-5} or better Recoil: 10^{-2} or better
 - Radiochemistry can provide high Z purity = $10^{-3} - 10^{-12}$
-
- Primary user or parasitic (2nd user) collection of A-separated species possible at both the ISOL and recoil separators



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Collection on the ISOL Mass Separator

Collector system at the focal plane of pre-separator
or at the Isobar separator

Parasitic beams

Hot Area

Main beam

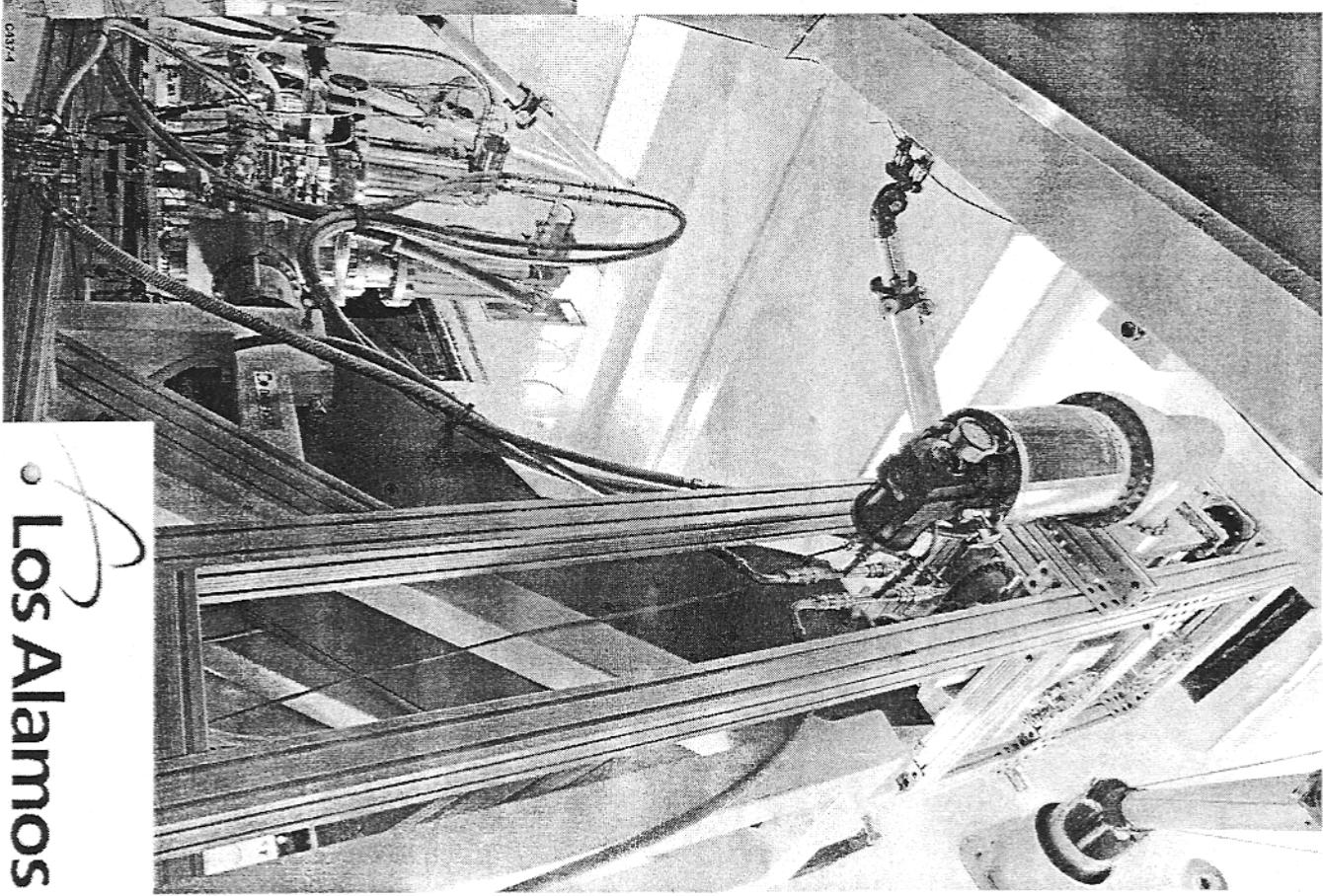
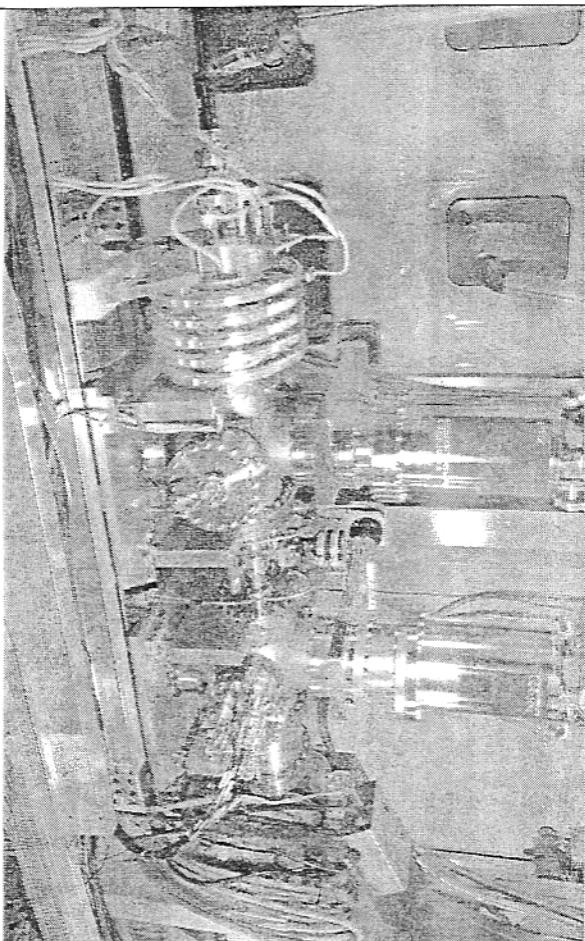
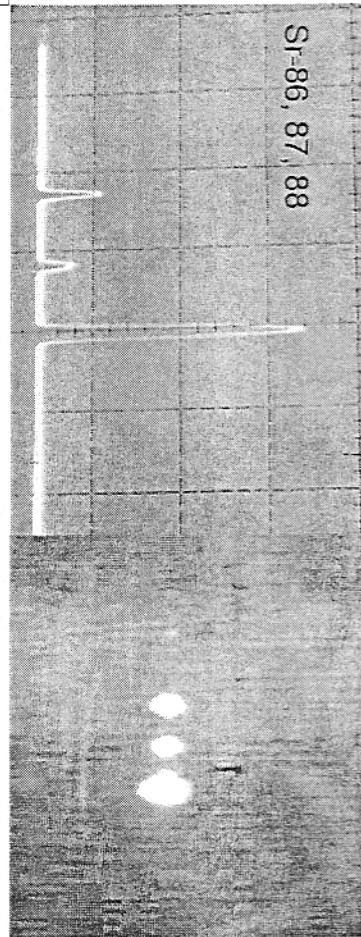
Vacuum interlock
to hot cell

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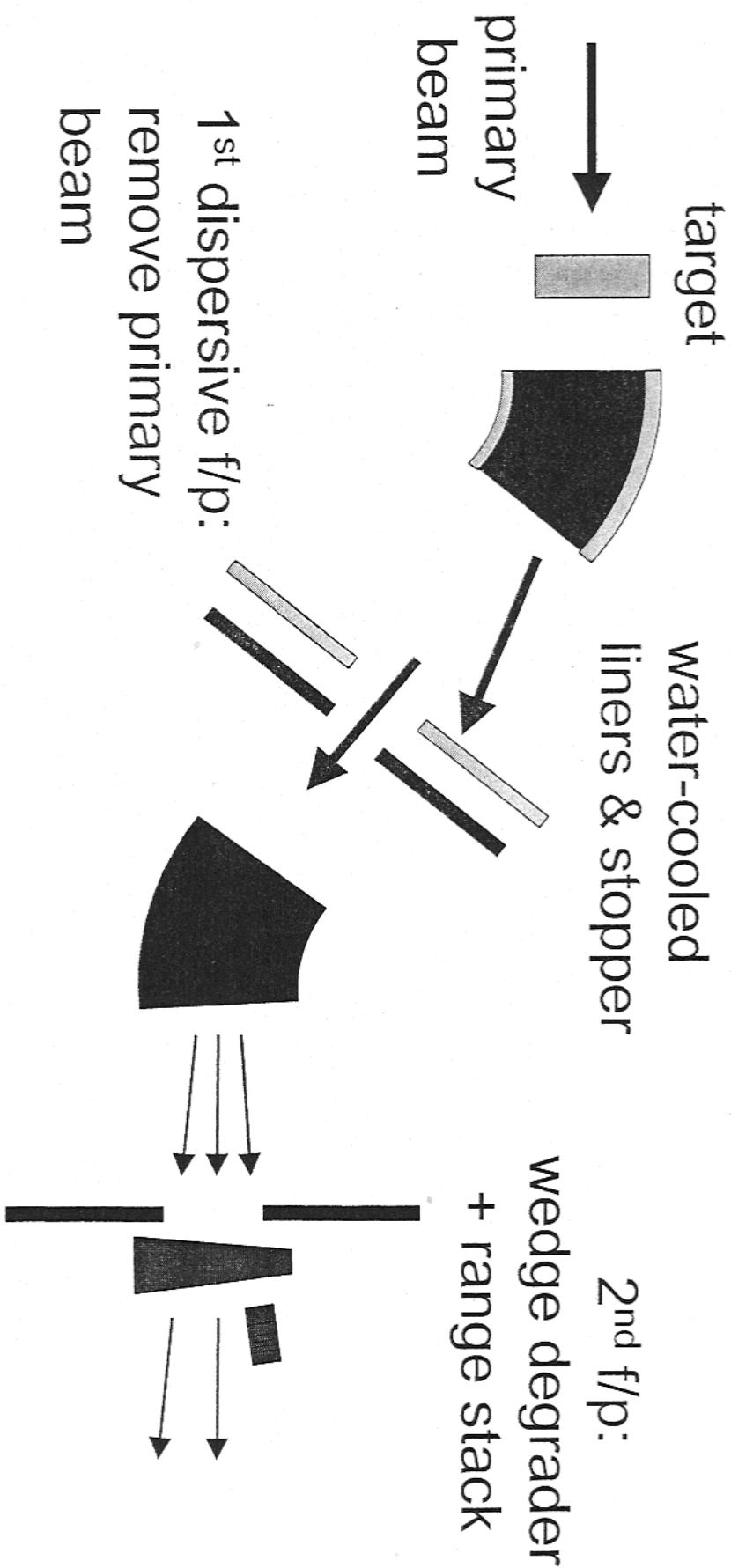
Radioactive Sample Isotope Separator (RSIS) at Los Alamos for DANCE radioactive targets

W.A. Taylor *et al.*



Los Alamos

Collection at the Recoil Separator



- utilize A/Q + range + radiochemistry to provide selectivity

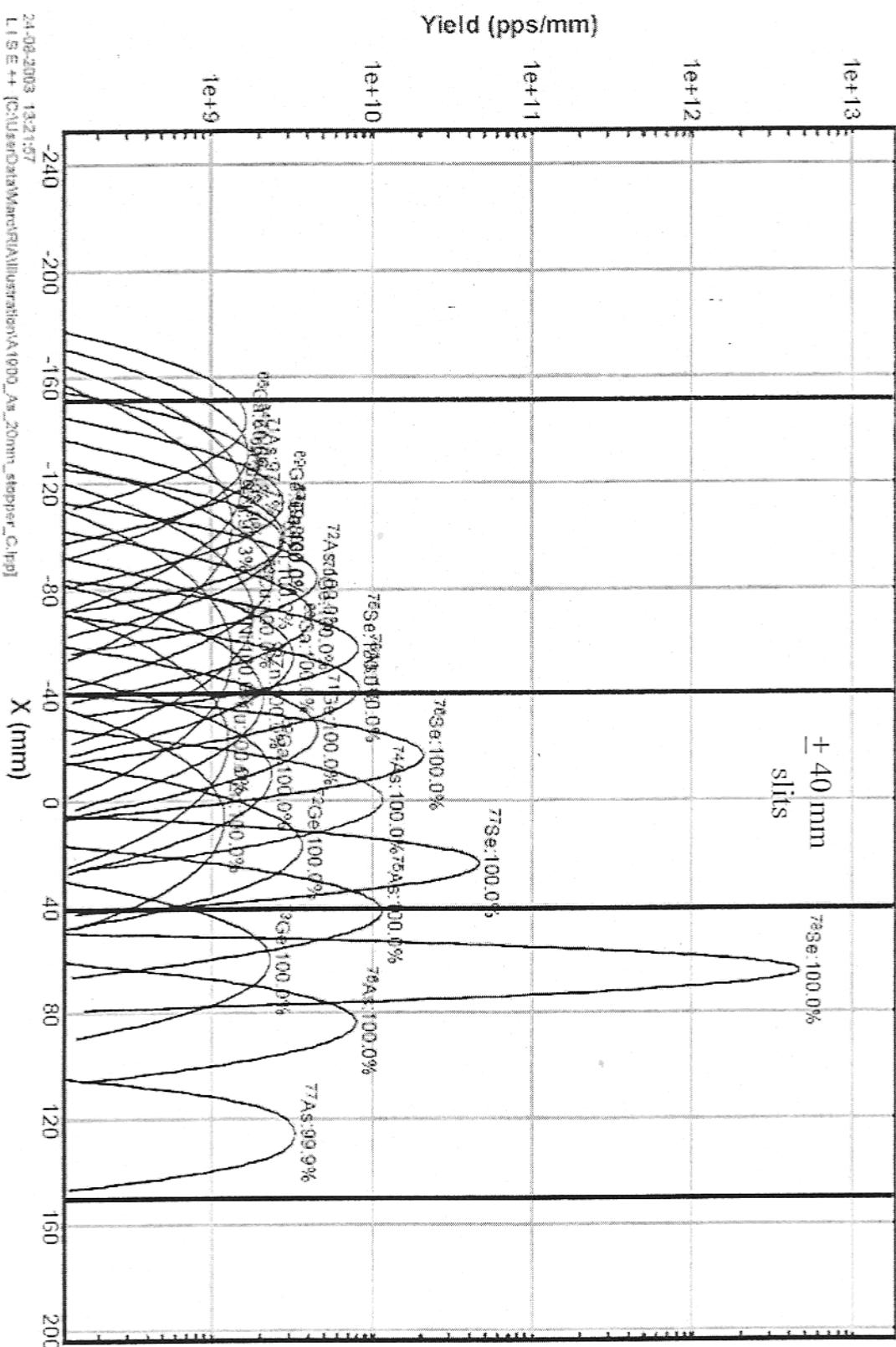
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HEMISTRY

LISE++ A1900
collection of n-def ^{74}As

D1-Xspace: output before slits
 ^{78}Se 400.0 MeV/u + Li (2000 mg/cm²); Settings on ^{74}As ; Config: D
 $\text{dp}/\text{p} = 10.39\%$; Brho(Tm): 6.2432

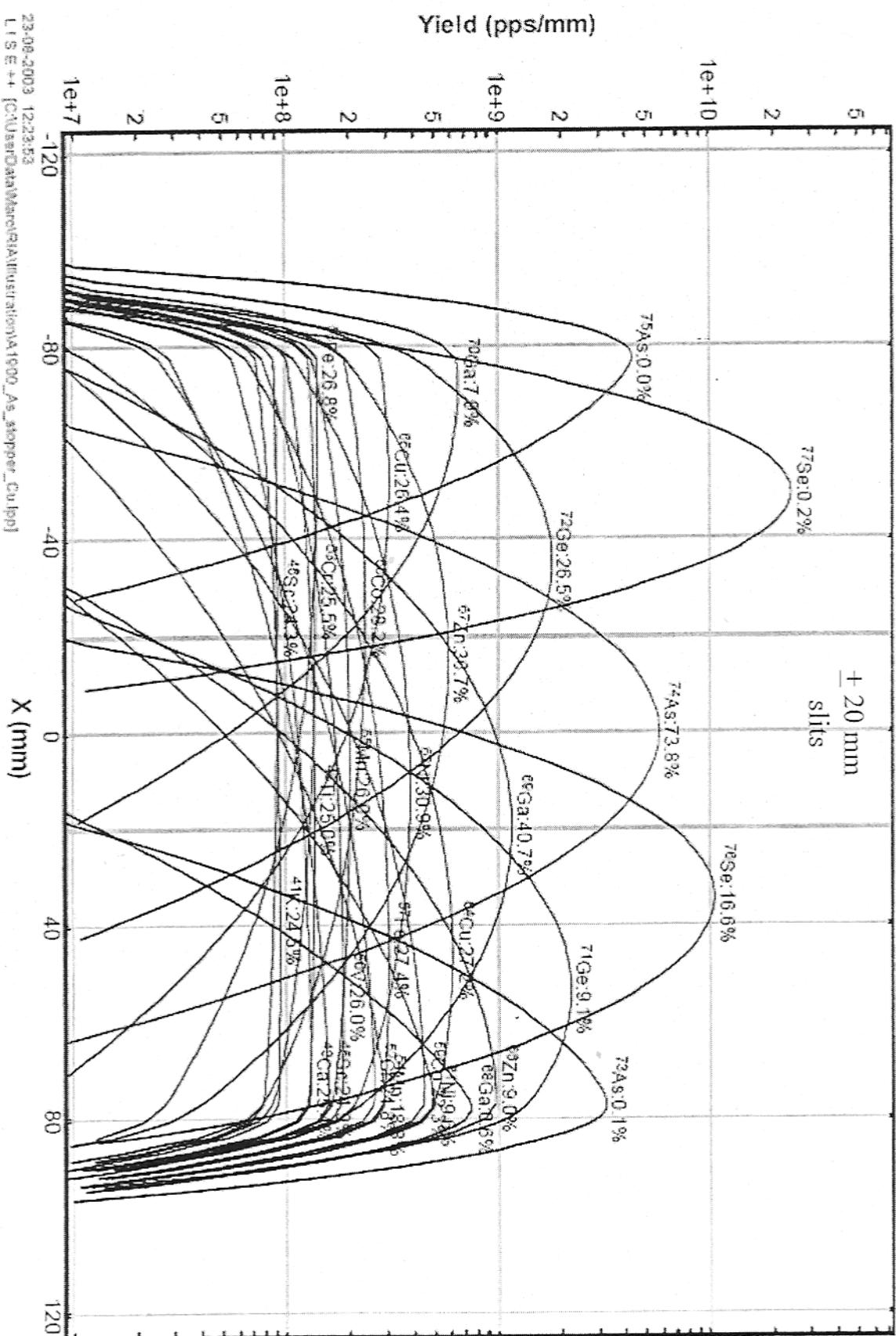
without charge states



Slits Im2-Xspace: output before slits

^{78}Se 400.0 MeV/u + Li (2000 mg/cm²); Settings on ^{74}As ; Config: DDMSM
 $d\mu/\mu = 0.68\%$; Brho(Tm): 6.2432, 6.2432

without charge filters

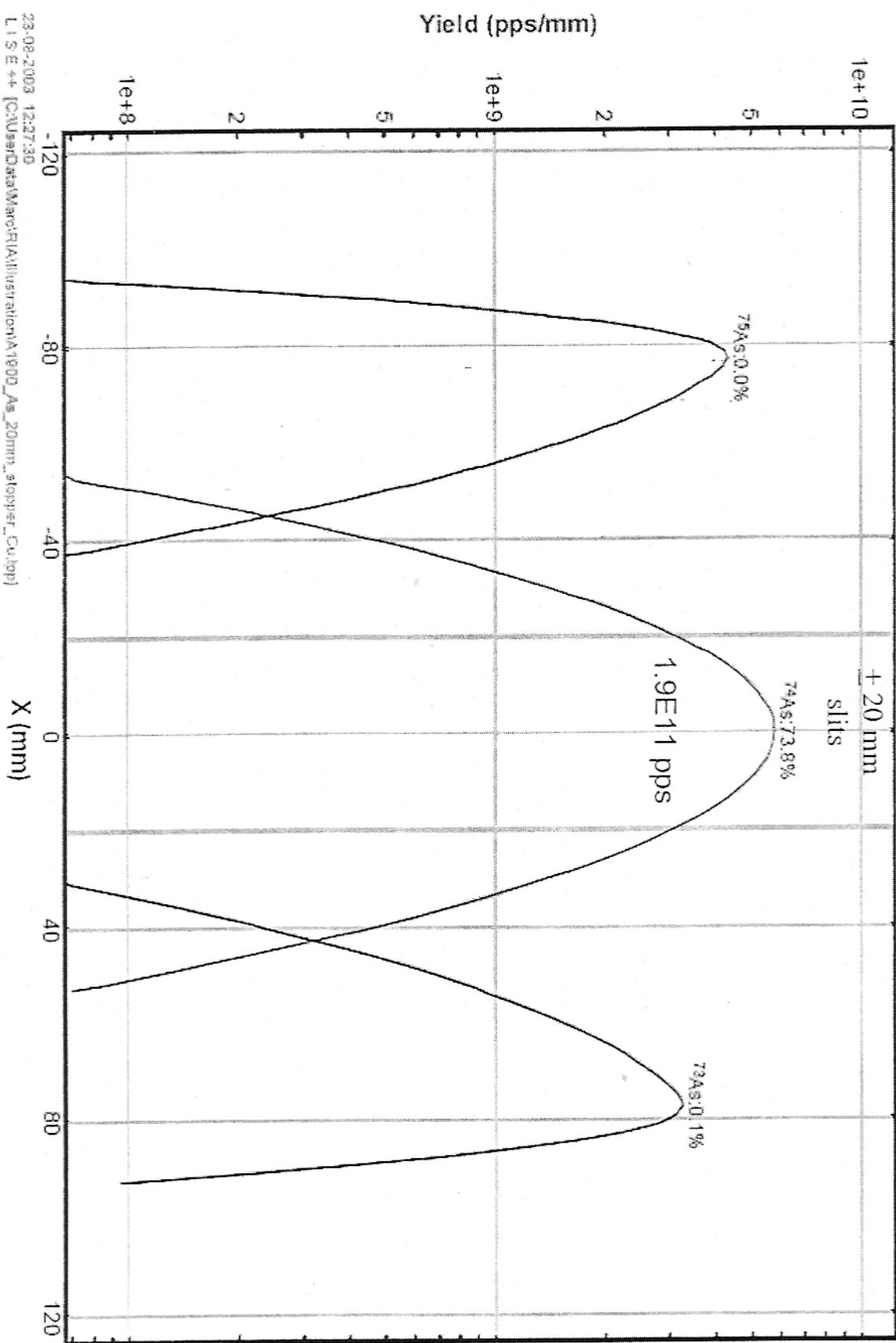


23-08-2003 12:23:53
LISE++ [C:\User\Marcel\RA\Illustration\As_stopper_Cu.ipp]

Slits_Im2-Xspace: output before slits

^{78}Se 400.0 MeV/u + Li (2000 mg/cm²); Settings on ^{74}As ; Config: DDMSM
 $d\text{p}/\text{p} = 0.68\%$; Brho(Tm): 6.2432, 6.2432

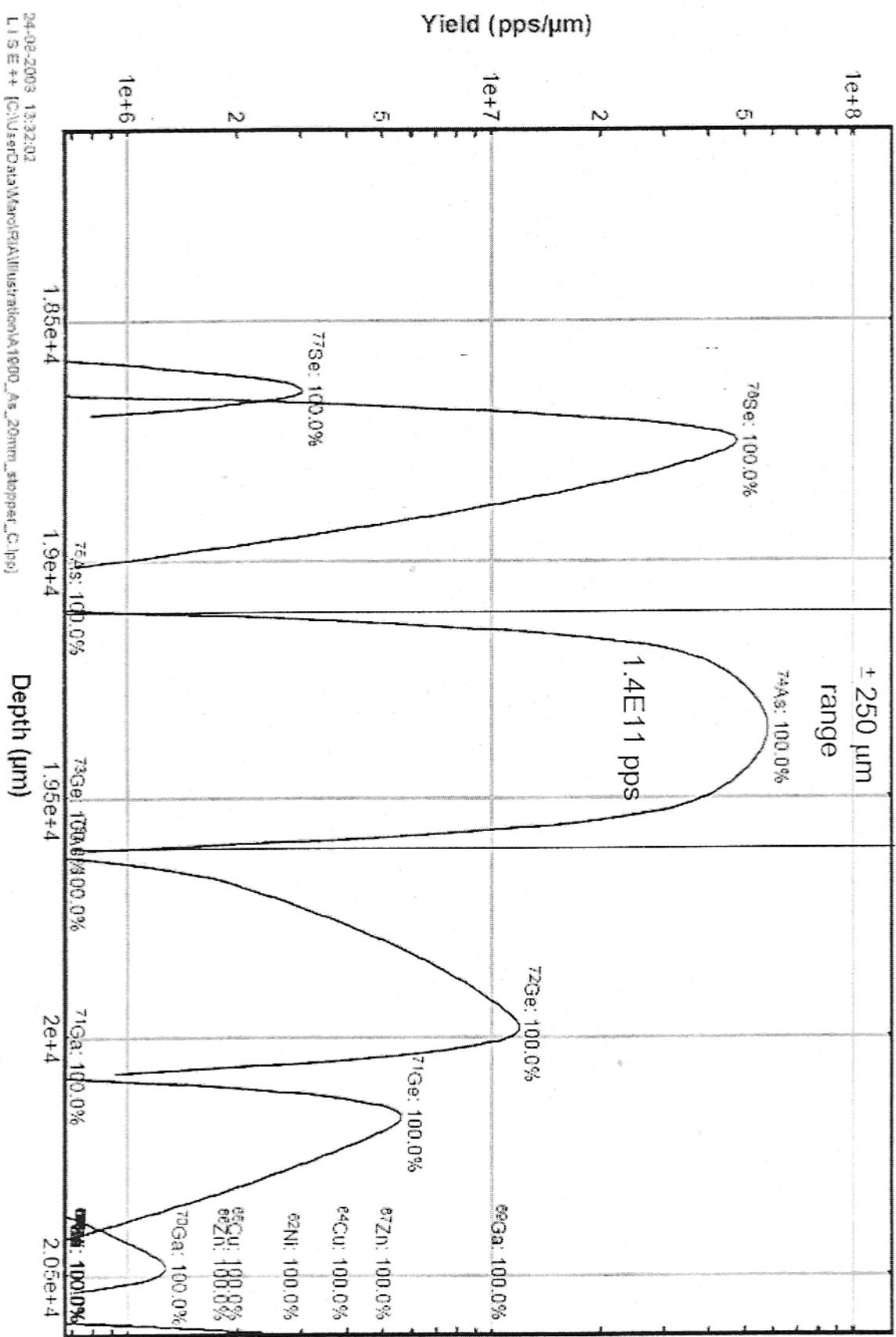
without charge states



Range distribution in Material 2

^{78}Se 400.0 MeV/u + Li (2000 mg/cm²); Settings on ^{74}As ; Config: DDMSM
 $d\mu/p = 0.68\%$; Brho(Tm): 6.2432, 6.2432

Material: C (56100 μm) Strag.Method: 1 (% stopped in detector [100% incoming into detector charge states])



Secondary Reactions in Range Stack

1. Secondary reaction losses of desired species (^{74}As)

~25% @ 320 MeV/u (1.9E11 -> 1.4E11 pps)

- ~2% neutron strip to ^{73}As (also long-lived, 4.0E9)

neutron-pickup leading to ^{75}As (stable) is hindered

- ~1.5% to more n-def. As (which β -decay to Ge isotopes)

- ~23% lead to Ge and light Z isotopes (removed in radchem.)

2. Other As isotopes + heavier Z isotopes that get thru slit 2

can undergo sec. rxns. and lead to isotopic impurity

- S2 + range cuts / pass thru -> ^{73}As (4.5E7) + ^{75}As (2.6E6)

- ^{76}Se (6.4E10) + ^{77}Se (1.6E9) -> ^{73}As (1.9E7) + ^{75}As (6.5E6)

total -> ^{73}As (6.4E7) + ^{75}As (9.1E6)

0.05% 0.0065%

➤ Can reduced the isotopic impurities caused by step 1 to ~1% level

by lowering the beam energy / target thickness, but this will
degrade the separation quality (step 2 contributions will increase)

- there is a compromise to be made here

➤ Collection of heavier Z species is more challenging due to
reduced recoil separation (closer proximity to the primary beam),
charge state interferences, wider range of sec. rxn. products

Collection of ^{74}As

Se72 8.5 d	Se73 7.1 h	Se74 0.9	Se75 120 d	Se76 9.1	Se77 7.6	Se78 23.6
As71 2.7 d	As72 26 h	As73 80 d	As74 18 d	As75 100	As76 26 h	As77 39 h
Ge70 20.5	Ge71 11 d	Ge72 27.4	Ge73 7.8	Ge74 36.5	Ge75 1.4 h	Ge76 7.8

Summary

1. High interest in collecting radioactive targets at RIA:
collection rates = 1 - 10 $\mu\text{g}/\text{day}$ (1 - 10 Ci)
2. Collection of species produced via the ISOL method is relatively straight forward and reasonable isotopic purities ($\sim 10^{-5}$) are expected
3. The recoil method is more universal, but recoil separation, secondary reactions, and Q states limit isotopic purities to the $\sim 10^{-2}$ level
4. Both parasitic (2nd user) and primary beam usage for preparing radioactive targets is anticipated
- collection ports and radiochemistry / hotcell capabilities should be designed into RIA upfront!
5. (Beam heating & radionuclide production due to primary beam is a big issue for the front-end of recoil separator!)

